

UNITED STATES PATENT APPLICATION
FOR
SUPPORT FOR NON-STANDARD DEVICE

INVENTOR:

SOO KEONG ONG,
a citizen of Malaysia

WEI KEE LAW,
a citizen of Malaysia

PREPARED BY:

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP
12400 WILSHIRE BOULEVARD
SEVENTH FLOOR
LOS ANGELES, CA 90025-1030
(303) 740-1980

EXPRESS MAIL CERTIFICATE OF MAILING
"Express Mail" Mailing No.

I hereby certify that I am causing the above-referenced correspondence to be deposited with the United States Postal Service "Express Mail Post Office to Addressee" service on the date indicated below and that this paper or fee has been addressed to the Mail Stop Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313 on August 1, 2003.

Name of Person Mailing Correspondence: Krista Mathieson

Krista Mathieson
Signature

August 1, 2003
Date

SUPPORT FOR NON-STANDARD DEVICE

FIELD

[0001] An embodiment of the invention relates to computers in general, and more specifically to support for non-standard devices.

BACKGROUND

[0002] In a computer environment, including an embedded computer or other specialized computer system, one or more devices may be connected to a bus. The devices and the bus may operate in compliance with a standard or specification, which may include a PCI (Peripheral Component Interconnect) standard.

[0003] However, a device in the environment that does not comply with the bus standard may also contain operational data. In addition, a standard device may operate as a non-standard device because the use of the device is non-complying. The data contained in the non-complying device may be the operating system (OS) for a system. In certain environments, the utilization of the data from the non-complying device or otherwise providing support for a non-standard device may cause complications in system operation, including a need for extensive modification to the BIOS (basic input output system) source code.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The invention may be best understood by referring to the following description and accompanying drawings that are used to illustrate embodiments of the invention. In the drawings:

[0005] **Figure 1** illustrates an embodiment of device connections;

[0006] **Figure 2** illustrates an embodiment of a system configuration;

[0007] **Figure 3** is a flowchart showing an embodiment of support for a non-standard device;

[0008] **Figure 4** is a flowchart showing an embodiment of selection of a standard device to provide support for a non-standard device; and

[0009] **Figure 5** is an embodiment of a computer.

DETAILED DESCRIPTION

[0010] A method and apparatus are described for provision of support for a non-standard device.

[0011] Under an embodiment of the invention, support is provided for a non-standard device that is operated in a standard computer environment. In one example, a system includes one or more standard devices coupled with a standard bus. The system further includes a non-standard device that contains certain data. The system identifies a standard device to associate with the data in order to allow utilization of the data in the system.

[0012] A standard that may be utilized in conjunction with an embodiment of the invention includes, but is not limited to, a PCI (Peripheral Component Interconnect) specification. Such specifications include the "PCI Local Bus Specification Rev. 2.1" ("PCI 2.1"), published on Jun. 1, 1995, the "PCI Local Bus Specification Rev. 2.2" ("PCI 2.2"), published on Dec. 18, 1998 and the "PCI Local Bus Specification Rev. 2.3" ("PCI 2.3"), published on March 29, 2002, by the PCI Special Interest Group. Such standards and related details are referred to herein as the PCI local bus specification or the PCI standard.

[0013] A non-standard device is a device that does not comply with a particular standard. A non-standard device includes a non-PCI device. A non-PCI device may be a device that is not configurable by configuration space decoding according to the PCI local bus specification. In addition, a standard device can be categorized as a non-standard device if the device is used in a non-standard way according to the applicable standard implementation. In one example, a flash memory may be a device that complies

with an ISA (Industry Standard Architecture) bus standard. However, the use of a flash device as a bootable device recognized by the BIOS is non-standard, and thus the flash device is a non-standard device for this purpose.

[0014] In one embodiment of the invention, a non-PCI device contains data comprising an OS, with the OS including an OS boot loader. An option-ROM may be created as the OS boot loader, but the option-ROM does not belong to any PCI device. In the embodiment, the option-ROM is used to cause the non-PCI device to be recognized as a standard bootable device, and thus allow the OS to be booted. The term option-ROM (or option ROM or expansion ROM) refers to optional read-only memory, also referred to as expansion memory. PCI Local Bus Specification, revision 2.3, section 6.3, provides additional information regarding this subject. An option-ROM can contain instructions required to properly boot or enable a peripheral device. According to an embodiment of the invention, a PCI device is selected to be associated with the option-ROM data, acting as a temporary target for the option-ROM. The association of the PCI device with data is used to dispatch software or firmware support for the non-PCI device to system memory.

[0015] According to an embodiment of the invention, software or firmware support is enabled for a non-standard device, such as a non-PCI device that has PCI option-ROM. The process may allow software component re-use, simplify the BIOS source code, and allow system development without requiring a full understanding of non-standard option-ROM programming.

[0016] According to an embodiment of the invention, one or more PCI buses are scanned for all PCI devices to locate a temporary target for option-ROM that does not

belong to a PCI device. A suitable PCI device is selected, and the selected PCI device's vendor ID and device ID are assigned to the option-ROM. The data may then be dispatched to memory in the same manner as data from a PCI device.

[0017] Each physical PCI device may include multiple functions (generally up to eight different functions) internally, with each function comprising a separate device. Each function may have the same or a different vendor ID and device ID as other functions included in the same physical device. For simplicity in this application, in addition to a physical device, "device" also refers to one of the functions for a physical device.

[0018] According to an embodiment of the invention, a device may act as a temporary target for an option-ROM if the device is a PCI compliant device without a physical ROM device. A suitable PCI device may have the following characteristics:

(1) The device is not a display adapter. A display adapter usually has associated PCI option-ROM, and thus the display adapter cannot provide a unique identifier for option-ROM in a non-PCI device.

(2) The device is not a PCI bridge. A PCI bridge device generally does not require a PCI option-ROM, thereby making the device unsuitable for identifying option-ROM.

(3) The device does not have on-board expansion ROM.

(4) The device is not already marked as used. According to an embodiment of the invention, selected PCI devices are marked as used so that such devices will not be assigned again to another PCI option-ROM that doesn't belong to PCI device.

[0019] According to an embodiment of the invention, a unique combination of vendor ID and device ID is chosen for an option-ROM, and this combination will not be used by other devices to dispatch other PCI option-ROMs. Through this selection process, it can be ensured that the data associated with an option-ROM is dispatched to the system memory, even though the option-ROM does not belong to any PCI device.

[0020] The process for selecting a PCI device as a temporary target will vary according to the embodiment. According to one embodiment, a PCI device may be pre-selected before commencing operations as a temporary target for an option-ROM. According to another embodiment, a selection process may be programmed into a function that is added into a BIOS kernel so that the BIOS kernel can perform the selection automatically.

[0021] According to an embodiment of the invention, the support is provided for a non-PCI device that appears as bootable item. According to an embodiment of the invention, a process is used in a board feature. The feature includes, but is not limited to, booting an operating system (OS) in a non-PCI device. The non-PCI device may include, but is not limited to, a non-volatile memory device, such as a flash memory device. A flash memory device may store operating system data (which may be referred to as OSFLASH or FLASHOS) that may be booted according to an embodiment of the invention. According to an embodiment of the invention, a system BIOS will recognize OS data stored in flash memory as equivalent to OS data stored in hard disk memory, and thus enable the booting of the system utilizing the OS in flash.

[0022] According to an embodiment of the invention, a method is provided to dispatch an OSFLASH boot loader to provide software or firmware support for flash

memory that comprises a non-PCI device. According to the embodiment, the OSFLASH boot loader is built as a PCI bootable option-ROM module. Not all PCI option-ROMs are bootable, with a special signature generally being required inside a PCI option-ROM in order for the option-ROM to be bootable. In an embodiment of the invention, a module header for an option-ROM contains a PCI device ID and vendor ID that can refer to one of the available PCI devices in the system. According to an embodiment, the BIOS kernel detects all available PCI devices and selects one of such devices to be the target of the OSFLASH boot loader. The selected PCI device then becomes a temporary target for the OSFLASH boot loader to be dispatched to system memory, with the real target of the OSFLASH boot loader being the non-PCI device flash memory.

[0023] In operation, system BIOS responsibility is to dispatch the each PCI option-ROM to system memory. The system BIOS reads each PCI device to identify the device ID and vendor ID, compares with all the option-ROM modules' device ID and vendor ID, and, if a match is found, the option-ROM is dispatched to system memory. According to an embodiment of the invention, an option-ROM of a non-PCI device is dispatched to memory in the same manner as other option-ROMs.

[0024] According to an embodiment of the invention, OSFLASH may be utilized without modifying an existing BIOS boot loader. Thus, existing BIOS logic is enabled for PCI option-ROM dispatching to dispatch the OSFLASH boot loader. OSFLASH may be utilized as a tool for embedded system end users to store customized OS in an onboard flash that shares storage with the system BIOS in the same device. The embedded OS may be supported with relatively low cost and with reduced software or

firmware development effort to develop and maintain the code of a modified BIOS boot loader.

[0025] **Figure 1** is an illustration of device connections according to an embodiment of the invention. In this illustration, a controller **105** is coupled with a standard bus **110**. The standard for the bus may include, but is not limited to, a PCI standard. The controller **105** is also coupled with a non-standard bus **115**, with at least one non-standard device **120** being coupled with the non-standard bus **115**. There are also one or more devices that comply with the standard coupled with the standard bus **110**, the standard devices being illustrated as standard device 1 **125** through standard device *n* **130**. The non-standard device **120** may contain operational data for the system, such as an operating system. In one example, the non-standard device **120** comprises a non-volatile memory device, such as flash memory. The operational data for the system may be stored in the non-volatile memory. However, the operational data generally would not be initiated through the non-standard device. Under an embodiment of the invention, one of the standard devices, **125** through **130**, is chosen as a temporary target for the operational data of the non-standard device **120**. When the chosen standard device is read, the operational data associated with the non-standard device **120** is dispatched to memory, allowing this data to be invoked when the memory is read.

[0026] **Figure 2** is an illustration of a system according to an embodiment of the invention. In this illustration, first controller **205** is coupled with a first bus **210**, which is a non-PCI bus, and with a second bus **215**, which is a PCI standard bus. The first controller may comprise an input/output controller hub (ICH) that performs functions that may be described as “Southbridge” functions. The first controller **205** is

coupled with a second controller **220**. The second controller may be a system address and data controller that performs functions that may be referred to as “Northbridge” functions. The second controller **220** is also coupled with a central processing unit (CPU) **225** and to memory **230**. One or more PCI devices, shown as PCI device 1 **235** through PCI device n **240**, are coupled with the PCI bus **215**. A non-PCI device **245** is coupled with the non-PCI bus **210**. The non-PCI device **245** may be a flash memory device or other non-volatile memory device. Certain operational data is associated with the non-PCI device **245**, such as an operating system, that should be dispatched to memory or otherwise supported. The first controller **205** normally would not boot the operational data from a non-PCI device. Under an embodiment of the invention, one of the PCI devices is chosen as a temporary target for the non-PCI device **245**. When the first controller **205** accesses the chosen target device, the data associated with the non-PCI device **245** is then transferred to memory **230** via the second controller **220**. In an example in which the data comprises an operating system, the CPU **225** accesses the data in the memory **230** and utilizes the operating system for operations.

[0027] **Figure 3** is a flowchart for support of a non-standard device **300** according to an embodiment of the invention. In this embodiment, the non-standard device contains certain data, such as an operating system. The data includes boot data, such as an OS boot loader. The boot data may be stored as an option-ROM. To support the non-standard device **300**, a standard device is chosen as a temporary target for the data contained in the non-standard device. For the purposes of this illustration, it is assumed that there is a plurality of standard devices available. A determination is made whether a standard device has been pre-selected as a temporary target for the

non-standard device data 305. If pre-selection has not been made, an auto-selection process is invoked 310. The auto-selection process may vary according to the particular embodiment. One example of an auto-selection process that may be implemented is illustrated in Figure 4 below. A standard device is either pre-selected or auto-selected as the temporary target, with the selected device being designated for this illustration as standard device A 315. Each standard device is read, such as by BIOS PCI logic for a PCI bus environment, and the vendor ID and device ID for each standard device is compared to the identification information provided for data (the option-ROMs that are present) 320, including the option-ROM for the non-standard device. When there is a match between the identification information for a standard device and the identification information for option-ROM, the data for the matched device is dispatched to memory 325. In particular, when Standard Device A is read, the data associated with the non-standard device option-ROM is dispatched to memory. The data contained in the memory is then read and the dispatched data is invoked. For example, if the data associated with the non-standard device comprises an operating system, then the data is booted and provides the operating system for the environment.

[0028] **Figure 4** is a flowchart illustrating an embodiment of selection of a standard device to provide support for a non-standard device 400. In this illustration, a PCI standard is involved, but embodiments of the invention are not limited to this standard. In this illustration, each standard PCI device contained in a system is examined to identify a device that can serve as a temporary target to provide support for a non-standard device. The scanning may involve one or more buses and any number of devices for each bus. In one embodiment, the scanning is conducted sequentially through

the devices, but devices can be scanned in any order. The configuration space registers of a device are read **405**. There is a determination whether the device is a valid PCI device **410**. If not, the scanning continues to the next PCI device **435**. If the device is a valid PCI device, the scanning then continues through determinations related to the suitability of the PCI device to act as a temporary target, with such determinations being made in any order. As shown in Figure 4, there are determinations whether the device is a PCI bridge device **415**; whether the device is a display adaptor **420**; whether the PCI device includes expansion ROM **425**; and whether the device has already been marked as used as a temporary target **430**. If any of the determinations are answered in the affirmative, the scan continues to the next device **435**. If the answers to all of the determinations are negative, then a valid combination of vendor ID and device ID has been located **440** and the PCI device is chosen as a temporary target for the non-PCI device **445**. The device is marked as used **450**, which prevents the use of the device as a temporary target for any other non-PCI device. The vendor ID and device ID for the option-ROM of the non-PCI device are updated with the vendor ID and device ID for the selected PCI device and the option-ROM checksum is updated **455**, thereby enabling the dispatch of the option-ROM data to memory.

[0029] Techniques described here may be used in many different environments. **Figure 5** is block diagram of an exemplary computer that can be used in conjunction with an embodiment of the invention. Under an embodiment of the invention, the computer may comprise an embedded system or other special purpose computer. An embedded system or other special purpose computer may operate without certain of the components and features described herein.

[0030] Under an embodiment of the invention, a computer **500** comprises a first bus **505** or other communication means for communicating information, and a processing means such as one or more processors **510** (shown as **511**, **512** and continuing through **513**) coupled with the first bus **505** for processing information. The first bus is a bus in compliance with a standard.

[0031] The computer **500** further comprises a random access memory (RAM) or other dynamic storage device as a main memory **515** for storing information and instructions to be executed by the processors **510**. Main memory **515** also may be used for storing temporary variables or other intermediate information during execution of instructions by the processors **510**. The computer **500** also may comprise a read only memory (ROM) **520** and/or other static storage device for storing static information and instructions for the processor **510**.

[0032] A data storage device **525** may also be coupled to the first bus **505** of the computer **500** for storing information and instructions. The data storage device **525** may include a magnetic disk or optical disc and its corresponding drive, flash memory or other nonvolatile memory, or other memory device. Such elements may be combined together or may be separate components, and utilize parts of other elements of the computer **500**.

[0033] According to an embodiment of the invention, a non-standard second bus **560** is included. A bus controller **555** controls bus operations. A non-standard device **565** is coupled to the second bus **560**. The non-standard device **565** may include, but is not limited to, a non-volatile memory device, including a flash memory device. In

one embodiment, an operating system for the computer **500** is stored on the non-standard device **565**.

[0034] The computer **500** may also be coupled via the first bus **505** to a display device **530**, such as a liquid crystal display (LCD) or other display technology, for displaying information to an end user. In some environments, the display device may be a touch-screen that is also utilized as at least a part of an input device. In some environments, display device **530** may be or may include an auditory device, such as a speaker for providing auditory information. An input device **540** may be coupled to the bus **505** for communicating information and/or command selections to the processor **510**. In various implementations, input device **540** may be a keyboard, a keypad, a touch-screen and stylus, a voice-activated system, or other input device, or combinations of such devices. Another type of user input device that may be included is a cursor control device **545**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **510** and for controlling cursor movement on display device **530**.

[0035] A communication device **550** may also be coupled to the first bus **505**. Depending upon the particular implementation, the communication device **550** may include a transceiver, a wireless modem, a network interface card, or other interface device. The computer **500** may be linked to a network or to other devices using the communication device **550**, which may include links to the Internet, a local area network, or another environment.

[0036] In the description above, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present

invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without some of these specific details. In other instances, well-known structures and devices are shown in block diagram form.

[0037] The present invention includes various steps. The steps of the present invention may be performed by hardware components or may be embodied in machine-executable instructions, which may be used to cause a general-purpose or special-purpose processor or logic circuits programmed with the instructions to perform the steps. Alternatively, the steps may be performed by a combination of hardware and software.

[0038] Portions of the present invention may be provided as a computer program product, which may include a machine-readable medium having stored thereon instructions, which may be used to program a computer (or other electronic devices) to perform a process according to the present invention. The machine-readable medium may include, but is not limited to, floppy diskettes, optical disks, CD-ROMs, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, magnet or optical cards, flash memory, or other type of media / machine-readable medium suitable for storing electronic instructions. Moreover, the present invention may also be downloaded as a computer program product, wherein the program may be transferred from a remote computer to a requesting computer by way of data signals embodied in a carrier wave or other propagation medium via a communication link (e.g., a modem or network connection).

[0039] Many of the methods are described in their most basic form, but steps can be added to or deleted from any of the methods and information can be added or

subtracted from any of the described messages without departing from the basic scope of the present invention. It will be apparent to those skilled in the art that many further modifications and adaptations can be made. The particular embodiments are not provided to limit the invention but to illustrate it. The scope of the present invention is not to be determined by the specific examples provided above but only by the claims below.

[0040] It should also be appreciated that reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature may be included in the practice of the invention. Similarly, it should be appreciated that in the foregoing description of exemplary embodiments of the invention, various features of the invention are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims are hereby expressly incorporated into this description, with each claim standing on its own as a separate embodiment of this invention.